

REMARKS

Claims 1-23 are pending in this Application. Claim 1 has been amended. Support for the amendment is found throughout the specification, including in claim 18. All pending claims have been rejected. Applicants respectfully request reconsideration in light of the following remarks.

The Examiner is thanked for a careful review of the claims, including each of the dependent claims, and thoughtful analysis.

Rejections Under 35 U.S.C. § 102

Claims 1-2, 6-18, 16-19, 21 and 22 are rejected under 35 U.S.C. 102(e) as being anticipated by U.S. Patent No. 6,274,008 to Gopalraja et al. ("Gopalraja"). Claims 1-2, 6-18, 16-17, 21 and 22 are rejected under 35 U.S.C. 102(e) as being anticipated by U.S. Patent No. 6,287,977 to Hashim et al. ("Hashim"). The cited patents have been fully considered and it is respectfully submitted that they do not prevent patenting of the claims.

Claim 1 relates to a method for depositing a diffusion barrier and metal conductive layer involving depositing first and second portions of a diffusion barrier, and then depositing a metal conductive layer. The claim recites, in part, the steps of (a) etching the bottoms of recessed features to clean at least part of an underlying metal while simultaneously depositing a first portion of a diffusion barrier on at least sidewalls of recessed features; wherein depositing a first portion of a diffusion barrier comprises sputtering metal from a target and (b) depositing a second portion of the diffusion barrier, which covers at least the bottoms of the recessed features.

Gopalraja describes a method of filling vias that involves three metallization steps: 1) a first step of highly ionized sputter deposition of copper, 2) a second step of lower-energy sputter deposition of copper to complete the copper seed layer, and 3) and electroplating copper into the hole to complete the metallization (abstract and Figure 16). In the embodiment depicted in Figures 14 and 15, Gopalraja shows forming a diffusion barrier layer (218) prior to the copper sputter depositions steps, which form a copper seed layer (226 and 228) on the sidewalls 222 and top of the dielectric. This process is also depicted in the flowsheet in Figure 16.

Unlike Gopalraja, claim 1 (operation (a)) recites etching the bottoms of recessed features to clean at least part of an underlying metal while *simultaneously* depositing a first portion of a diffusion barrier before depositing a second diffusion barrier portion (operation (b)). As

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indicated above, Golparaja describes forming only one diffusion barrier layer (218) in the via. There is no teaching or suggestion that the bottom of the via is simultaneously etched while this barrier layer is deposited as required by operation (a). Moreover, there is no teaching or suggestion that forming a second portion of a diffusion barrier in Golparaja. Layer 228 – cited by the Examiner as the second portion of a diffusion barrier – is a copper seed layer (col. 13, lines 28-31). Applicants were unable to find any mention of a second portion of a diffusion barrier in the reference.

Hashim describes etching a barrier layer at the bottom of a via to expose the underlying metal layer and subsequently depositing another metal layer over the exposed underlying metal layer. In Figures 4A-D and the accompanying text, Hashim describes sputter etching a silicon nitride barrier layer and redistributing the silicon nitride material along the sidewalls. Applicants acknowledge the Examiner's position that Hashim meets the limitations of operation (a) by "simultaneously depositing a first portion of a diffusion barrier on at least sidewalls of recessed features (fig. 4B)." It is respectfully submitted that "depositing" a material as claimed is distinct from redistributing as in Hashim. Nevertheless to clarify that the claimed "depositing" is not redistributing, claim 1 has been amended to recite that "depositing a first portion of a diffusion barrier comprises sputtering metal from a target."

Applicants also submit that claim 6 is not anticipated by Hashim. Claim 6 specifies that the recessed features are trenches of a single damascene structure. Hashim shows methods of forming copper interconnects and does not teach or suggest forming a barrier layer in a trench.

In view of the above, it is respectfully submitted that claim 1, and all of its dependent claims, are not anticipated by either Golparaja or Hashim.

Rejections Under 35 U.S.C § 103

Claims 3-5, 9-15, 20 and 23 are rejected under 35 U.S.C 103(a) as being unpatentable over Golparaja. Claims 3-5, 9-15, 18-20 and 23 are rejected under 35 U.S.C 103(a) as being unpatentable over Hashim.

As described above, Applicants method includes the steps of (a) etching the bottoms of recessed features on a surface of the substrate to clean at least part of an underlying metal while simultaneously depositing a first portion of a diffusion barrier on at least sidewalls of recessed features; wherein depositing a first portion of a diffusion barrier comprises sputtering metal from a target and (b) depositing a second portion of the diffusion barrier, which covers at least the

bottoms of the recessed features. The methods of Applicants' invention have various advantages. For example, in some embodiments, the methods of Applicants' invention allow little or no barrier to be deposited on the feature bottom early in the process, which may be desirable to reduce etch time and increase throughput (see, e.g., page 5, lines 7-10).

The Examiner contends that Golparaja lacks anticipation only in not teaching the various features of these dependent claims, including etch-to-deposition ratios, etc., and that the claimed ranges and features are parameters of optimization to one of ordinary skill in the art. Applicants submit that there is no teaching or suggestion of recited elements of operations (a) and (b) of claim 1, as discussed above with respect to the 35 U.S.C § 102 rejection.

With respect to the rejection over Hashim, the Examiner contends that Hashim lacks anticipation only in not teaching the various features of the dependent claims, including etch-to-deposition ratios, etc. Applicants submit that claim 1, as amended, as well as the various features of these dependent claims are not taught or suggested by Hashim. As indicated above, Hashim describes sputter-etching the bottom of the via, thereby redistributing the silicon nitride material at the bottom of the via to the sidewalls. As taught in Hashim, this is accomplished by sputter-etching only (i.e., with a DC power of 0) (col. 13, lines 8, lines 56-67; col. 7, lines 45 and 46). Hashim does not teach or suggest depositing a first portion of barrier material by sputtering metal from a target. This distinction is important because the methods of Hashim shown in Figs. 4A-4B require depositing barrier material at the bottom of the via early in the process, thereby increasing process time.

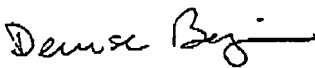
In addition for the reasons given above with respect to claim 1, Applicants submit that claim 6, which specifies that the recessed features are trenches of a single damascene structure, is independently patentable. As discussed in Applicants' specification, certain embodiments of the invention are useful for low aspect ratio features such as trenches in single damascene structures where barrier material deposits more thickly, making it difficult to etch through (see, e.g., pages 4-6, 10 and 11). Hashim shows methods of forming copper interconnects and does not teach or suggest forming barrier layers in a trench.

In view of the above, it is respectfully submitted that claim 1, and all of its dependent claims, are patentable over Golparaja and Hashim. Withdrawal of all rejections is respectfully requested.

Conclusion:

In light of the foregoing amendments and remarks, Applicants respectfully submit that all pending claims are now in condition for allowance. Thus, Applicants respectfully request a Notice of Allowance from the Examiner. Should any unresolved issues remain, the Examiner is encouraged to contact the undersigned at the telephone number provided below. No fees appear to be necessary for this Amendment. However, if the Commissioner determines that any fee is due, such fee may be charged to deposit account No. 500388 (Order No. NOVLP024X2).

Respectfully submitted,
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